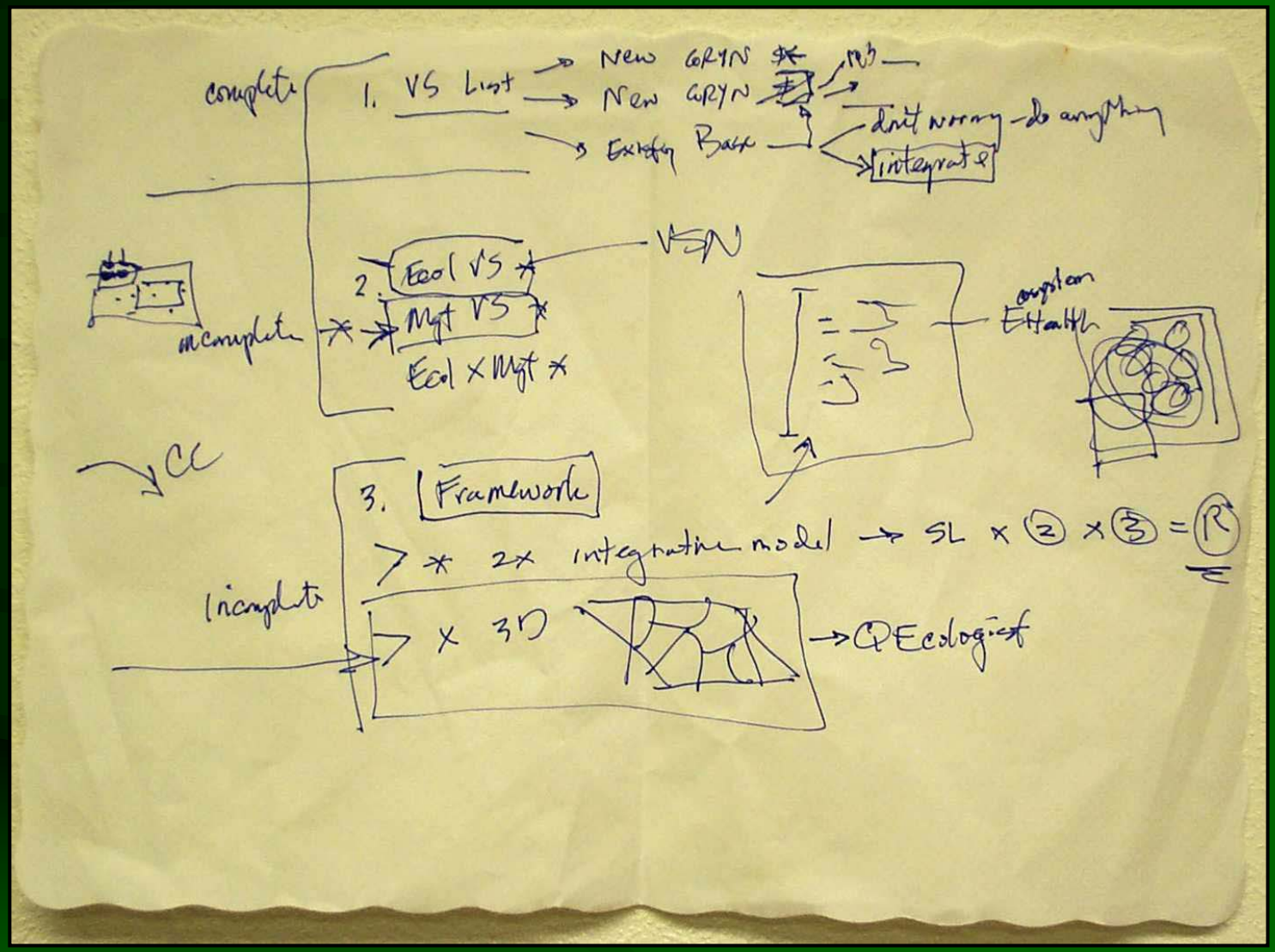


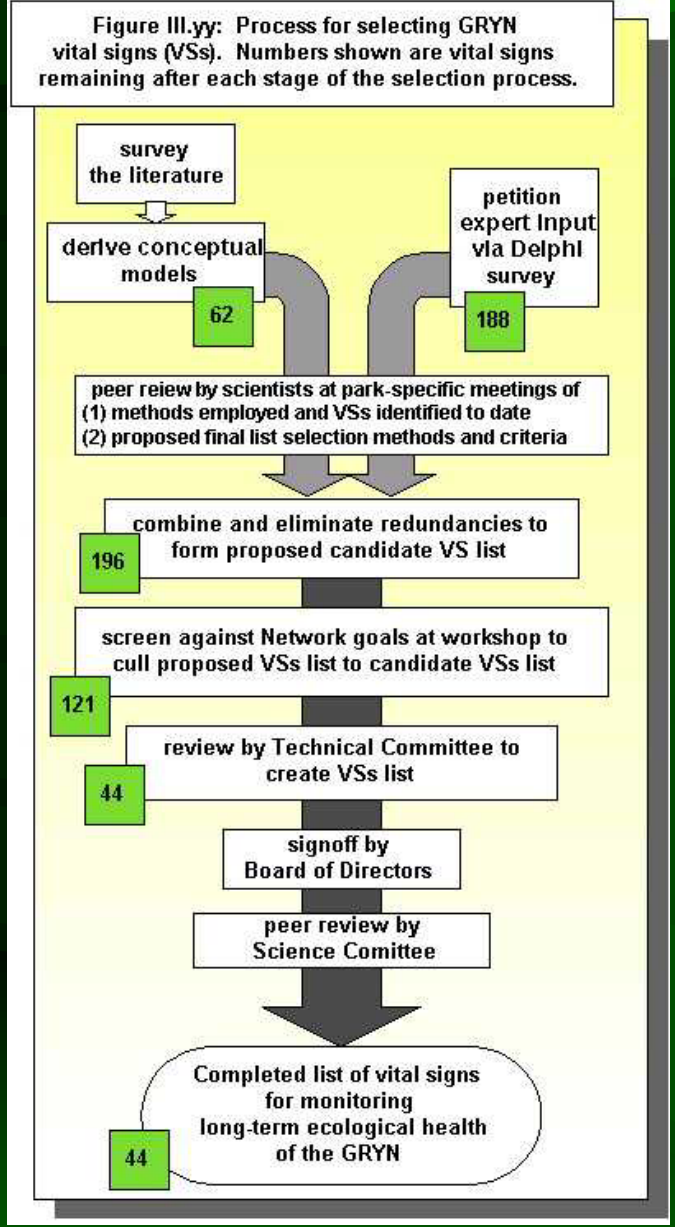
Greater Yellowstone Network I&M Program

A 2003 case study from the Greater Yellowstone Network on Choosing Vital Signs

By Cathie Jean
Program Manager

	Resource / Ecological Organization	Selected Vital Signs	Existing Program (p=partial, n=no)	Requires GRYN Funding (y=yes, n=no, o=needs outside funding)	Top Priorities	Park relevance		
						GRTE	YELL	BICA
2	Aquatic Biotic	Exotic aquatic community structure and composition	p	Y	X	x	x	
3	Aquatic (water)	Springs and seeps distribution and hydrology	n	Y	X	x		x
4	Aquatic (water)	Streamflow	p	Y	X	x	x	x
5	Aquatic (water)	Water chemistry	p	Y	X	x	x	x
6	Aquatic (water)	River invertebrate assemblages	p	Y	X	x	x	x
7	Climatic	Basic climatological measurements	p	Y	X	x	x	x
8	Terrestrial Biotic	Amphibian occurrence	p	Y	X	x	x	x
9	Terrestrial Biotic	Whitebark pine decline	p	Y	X	x	x	
10	Geologic (geothermal)	Heat flow - Chloride flux	p	Y	X	x	x	
11	Human	Land-use change and habitat fragmentation	p	Y	X	x	x	x
12	Terrestrial Biotic	Exotic plant species abundance and distribution	p	Y	X	x	x	x
13	Aquatic Biotic	Native aquatic community structure, composition, stability and genetic integrity	p	Y		x	x	x
14	Aquatic Biotic	Algal species composition and biomass	n	Y		x	x	x
15	Aquatic Biotic	E. coli *(Escherichia coli)*	p	Y				x
16	Aquatic (water)	Groundwater quantity and quality	p	Y		x	x	x
17	Aquatic (water)	Reservoir elevation		N		x		x
18	Aquatic (water)	Continuous water temperature	p	Y		x	x	x
19	Atmospheric	Atmospheric deposition of nitrogen, sulfur and all major anions and cations (including wet and dry deposition)	p	Y		x	x	x
20	Atmospheric	Change in visibility deciviews	p	Y		x	x	x
21	Climatic	Glacial retreat or advance		Y		x		
	Geologic	Stream sediment transport	p	Y		x	x	x

Greater Yellowstone Network I&M Program



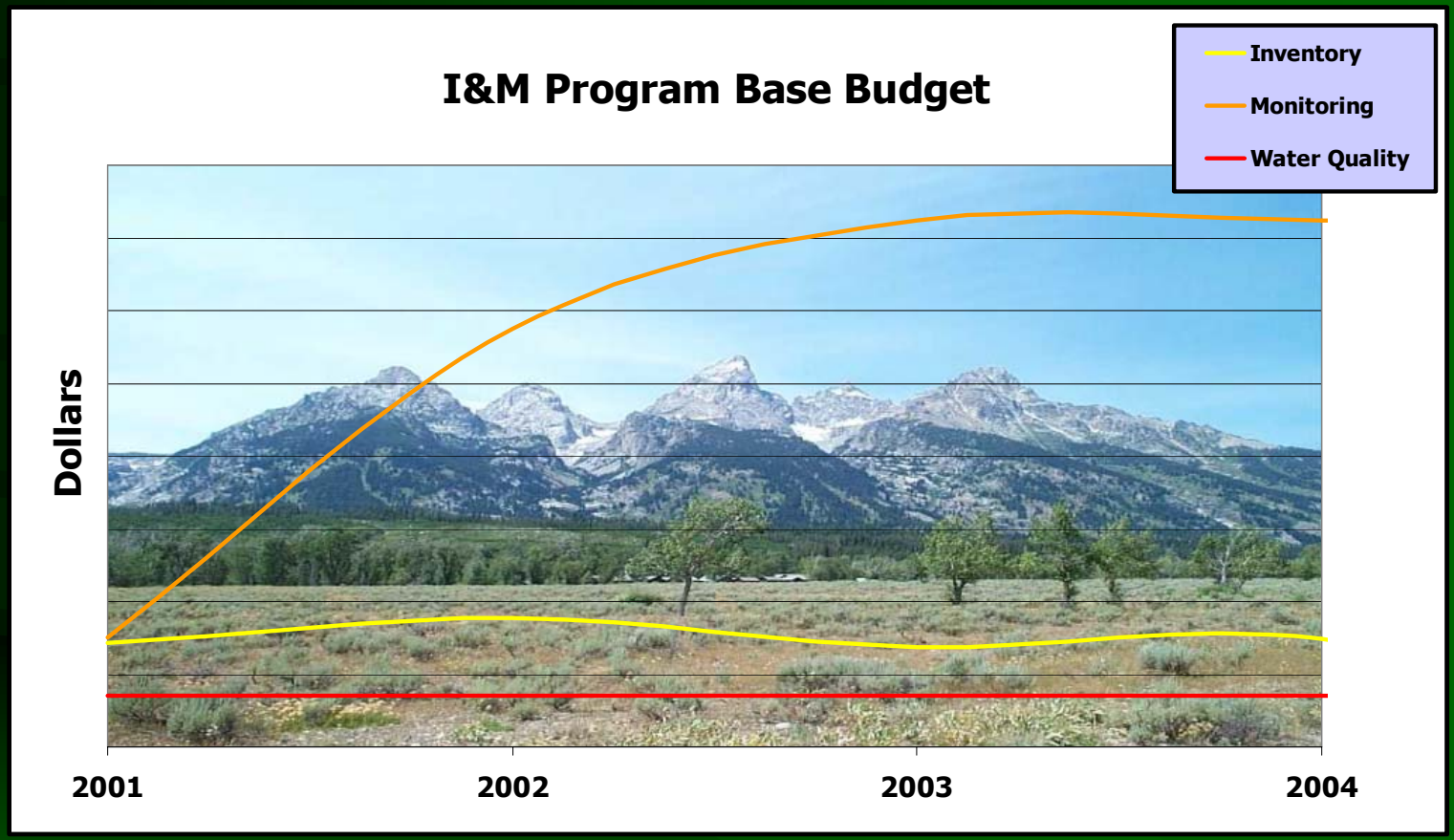
- Choosing Vital Signs:
  - Nominating
  - Filtering and ranking
  - Choosing and selecting priorities
  - Peer review
  - Approval

GRYN Vital Signs Planning Schedule

October 2002 September 2002	**Develop institutional framework for I&M Program** • summarize information and concepts for vital signs monitoring • solicit expert opinion to expand science foundation	Phase I (Chapters II, III)
February 2003 March 2003 May 2003 June 2003 July 2003 September 2003	**Identify Vital Signs** • define attributes and criteria to filter and rank vital signs • sponsor park workshops to solicit input from park staff • refine criteria and apply to candidate list **Sponsor workshop to solicit expert opinion** • present objectives to Technical Planning Committee and Science Committee • solicit Superintendents' review and approval **Submit Phase II Report for peer review**	Phase II (Chapters II, III, IV)
December 2004	**Develop sampling design and protocols** • data management plans • submit Monitoring Plan for peer review	Phase III (Chapters I-XII)
December 2005	**Submit Final Vital Signs Monitoring Plan**	

Greater Yellowstone Network I&M Program

GRYN Program Funding



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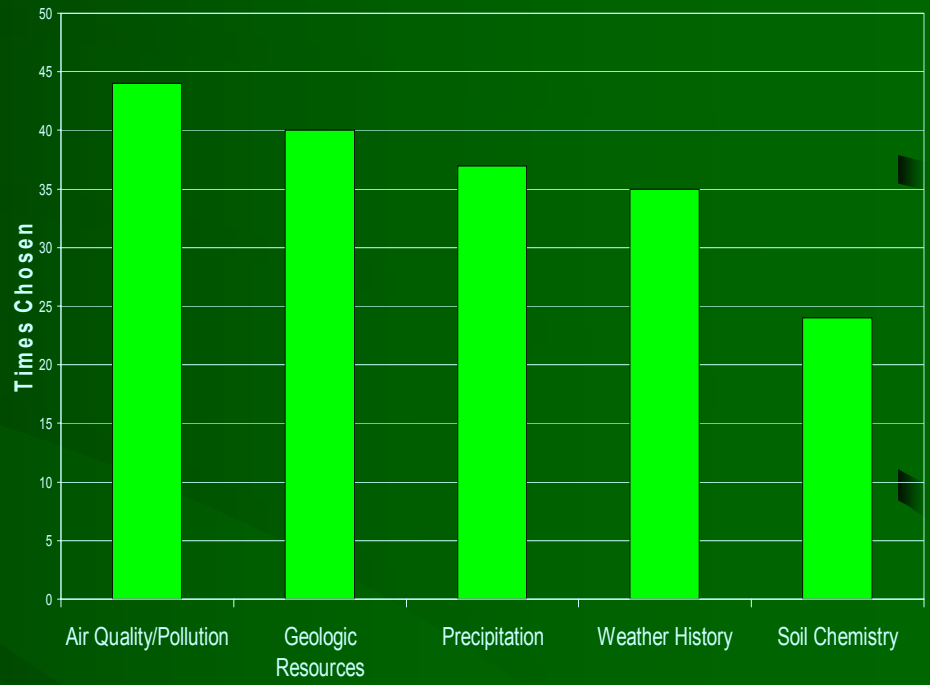
Vital Signs identified using a Delphi Internet survey

- **Delphi nominated Vital Signs**
- Glacial retreat and advance
- Weather measurements
- Forest carnivores
- Noise (Soundscape)

Delphi I-III: Participants nominate and rank candidate vital signs (CVS)

- We evaluated:
  - 188 CVS divided into 8 categories
  - Average importance value assigned to each CVS.
  - Sample size <20 per CVS.



Delphi Importance Score

- **Importance Score**
  - 5 = Highly Important
  - 4 = Very Important
  - 3 = Moderately Important
  - 2 = Slightly Important
  - 1 = Not at all important
  - 0 = No answer provided

AIR QUALITY INDICATORS

Importance Score	Measurement	Explanation
Change in Visibility deciviews	**Change in Visibility deciviews**	**Change in Visibility deciviews**
4	4	YELL and GRTE are Class 1 areas. Threats to visibility from new energy development near all three parks are imminent.
4	4	Important for Class I YELL and GRTE, but already measured by IMPROVE, so I&M doesn't need to fund

Importance Score	Measurement	
Change in Visibility deciviews	**Change in Visibility deciviews**	
Average		
0.32		
N=24	N=19	
6		
7	Change in	8
8	Direct Measure	7
3	Indirect measure	0
0	Patterns of	4
6		11
30		30 Total

(N = number who actually answered each)

Importance Score
5 = Highly Important
4 = Very Important
3 = Moderately Important
2 = Slightly Important
1 = Not at all important
0 = No answer provided

Delphi III- Air Quality Indicators

- Loading chem species in snowpacks 3.85
- Atmospheric deposition of S 3.78
- Acid neutralizing capacity in headwater lakes 3.54
- Accumulation toxic air contaminants in biota 3.52
- Change in visibility deciviews 3.52
- Atmospheric deposition on N 3.46
- Loss of forest productivity 3.46
- Ozone exposure index--W126 3.14

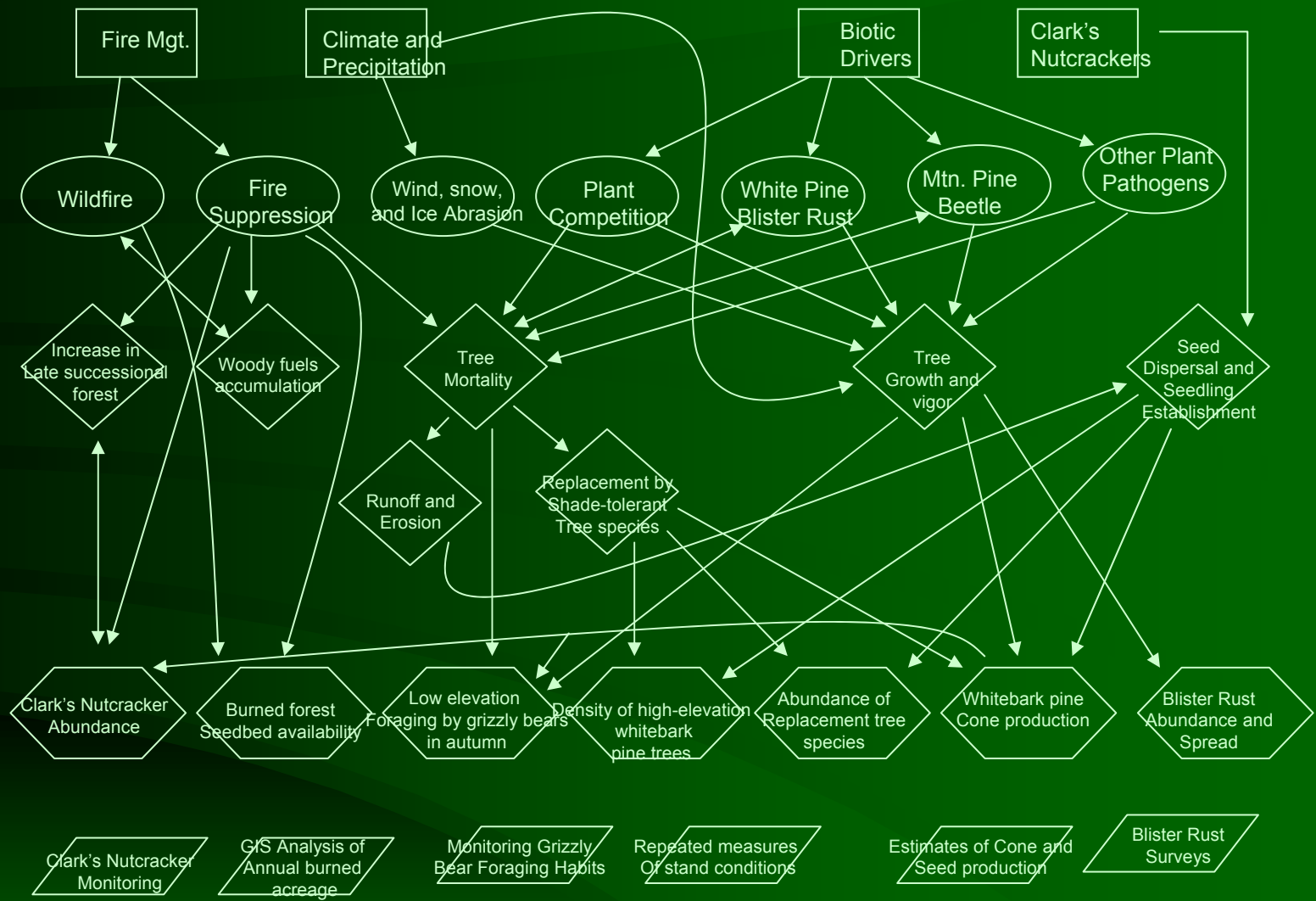
Lessons learned: Delphi

- Benefits: Obtain many ideas from a large audience
- Participants dispersed in time and space, e.g. no face to face interaction or group think
- Rapid and efficient (no travel time or costs)
- Valuable feedback opportunities
- Disadvantages: Numerous authors submitted incongruent vital sign names and definitions.
- No certainly that the participants understand the subject material or the ranking process.
- Our conclusion: Our approach good as a vital signs nomination process but the ranking process will not substitute for a more defensible ranking and decision process

Conceptual Model Approach

- Conceptual models helped us identify and communicate important components of the ecosystem and the interactions among them.
  - We used schematic and narrative models to evaluate terrestrial and aquatic drivers, stressors, responses, outcomes and suggest potential indicators

Draft Whitebark Pine Model - Tinker



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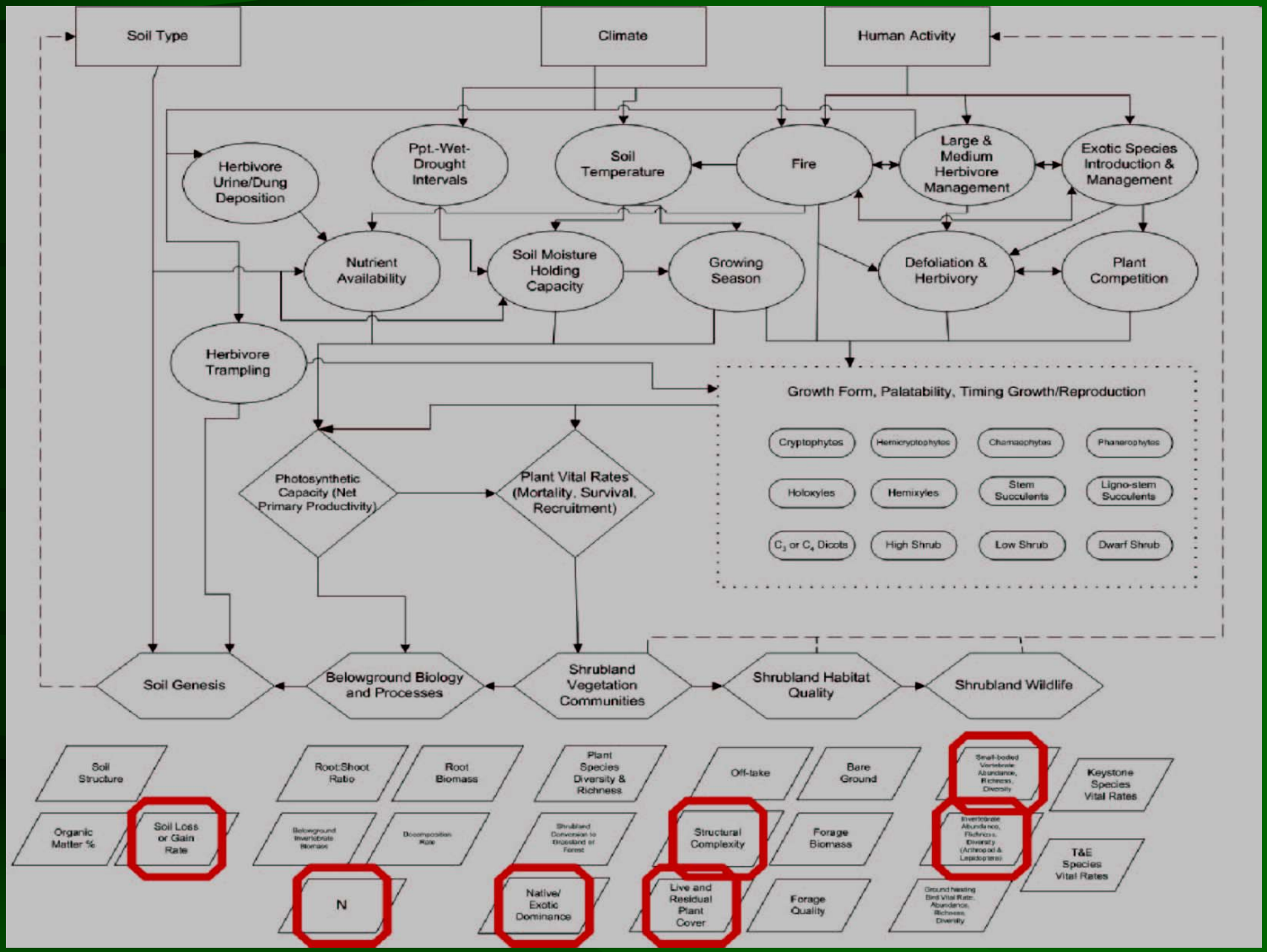

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Conceptual Model Indicators

- Benefits: Ecological relevance of candidate vital signs tied to ecosystem drivers, stressors and outcomes
- Candidate Vital Signs supported with scientific literature
- Good communication tool

- Disadvantages: Framework generalized to cover broad terrestrial and aquatic ecosystem types; small special case situations and large scale regional indicators potentially overlooked.

Vital Signs Workshop Goals

- Create a shared understanding of the NPS I&M Program and the Greater Yellowstone Network
- Apply the selection criteria from the decision support system to each candidate vital sign in the topic area and score the results
- Document comments related to the scoring decisions that will be incorporated into a report for the Technical and Science Committees
- Build a spatial and temporal conceptual framework that integrates across scales

All Candidate Vital Signs

Grouped by Primary and Secondary Resource

Resource	Candidate Vital Sign	
Air Quality		
	Biotic and Abiotic	
	Accumulation of toxic air contaminants in biota	AiQu_004
	Acid Neutralizing Capacity in headwater lakes	AiQu_003
	Atmospheric deposition of N	AiQu_006
	Atmospheric deposition of S	AiQu_002
	Change in visibility deciviews	AiQu_005
	Deposition of trace organics and metals	AiQu_010
	Loading chem species in snowpacks	AiQu_001
	Loss of forest productivity	AiQu_007
	Nitrogen concentration in streams during spring snowmelt	AiQu_009
	Ozone exposure index--W126	AiQu_008
	Vegetation chemistry	AiQu_207
Aquatic Communities		
	Aquatic Exotic species	
	Exotic fish abundance	AqCo_130
	Exotic fish distribution patterns	AqCo_131
	Aquatic Pathogens/disease	
	Fish pathogens/disease	AqCo_133

File Edit View Insert Format Records Tools Window Help

1. Give the Vital Sign a descriptive name

Find a Record

Vital Sign Name: Loading chem species in snowpacks

Create a NEW Candidate Vital Sign

5. Create a unique ID by pressing this button

Create Unique ID

1

AiQu_001

2. Choose a value from each list

Primary Resource: Air Quality

Secondary Resource: Biotic and Abiotic

Theme:

6. Add known metrics and protocols

Measure	Protocol

Record: 1 of 1

3. Why is this a good Vital Sign?

Justification: This indicator was nominated during the Internet based Delphi Survey. Justification for this Vital Sign as well as concerns with this Vital Sign are posted in the Comment Field

7. Legislation associated with the Vital Sign

Is this Vital Sign associated with legislation?

If so, which legislation?

4. Any other relevant information

Comments: As snow accumulates both wet and dry deposition over a long period of time, a measurement such as chemical loading of species in snowpack could be informative especially if other system measurements suggested that such loading could be significant and potentially harmful. generally, measurement of acid

8. Source of this Vital Sign

Source: Delphi

Close Form

Add New Record

Undo Record

rd: 1 of 196

ue attribute identifier or code

Vital Signs Selection Criteria

- Ecological Relevance
- Response Variability
- Management Relevance
- Feasibility of Implementation
- Interpretation and Utility

Greater Yellowstone Network Vital Signs Planning Workshop — Bozeman, MT. May 6-8, 2003

- **Vital Sign:** → → → → → → → ¶
- Primary Resource: ¶
  Secondary Resource: ¶

¶
¶
¶

Parks that this Vital Sign applies to: ¶
¶
YELL ····· GRTE → BICA ¶

VITAL SIGN CRITERON	Yes	No	Comments
Ecological Relevance ¶ ¶ • → The candidate vital sign has high ecological importance with a demonstrated linkage between the vital sign and the ecological structure or function that it is supposed to represent, based on a conceptual model and/or supporting ecological literature ¶ ¶ • → The candidate vital sign provides relevant information that is applicable to multiple scales of ecological organization ¶	O ¶ O	O ¶ O	
Response Variability ¶ ¶ • → The candidate vital sign responds to ecosystem stressors in a predictable manner with known statistical power ¶ ¶ • → The candidate vital sign is anticipatory and is sensitive enough to stressors to provide an early warning of change ¶ ¶ • → The candidate vital sign has low natural variability and has high signal-to-noise ratio (e.g. low error) ¶	O ¶ O ¶ O	O ¶ O ¶ O	

Greater Yellowstone Network I&M Program

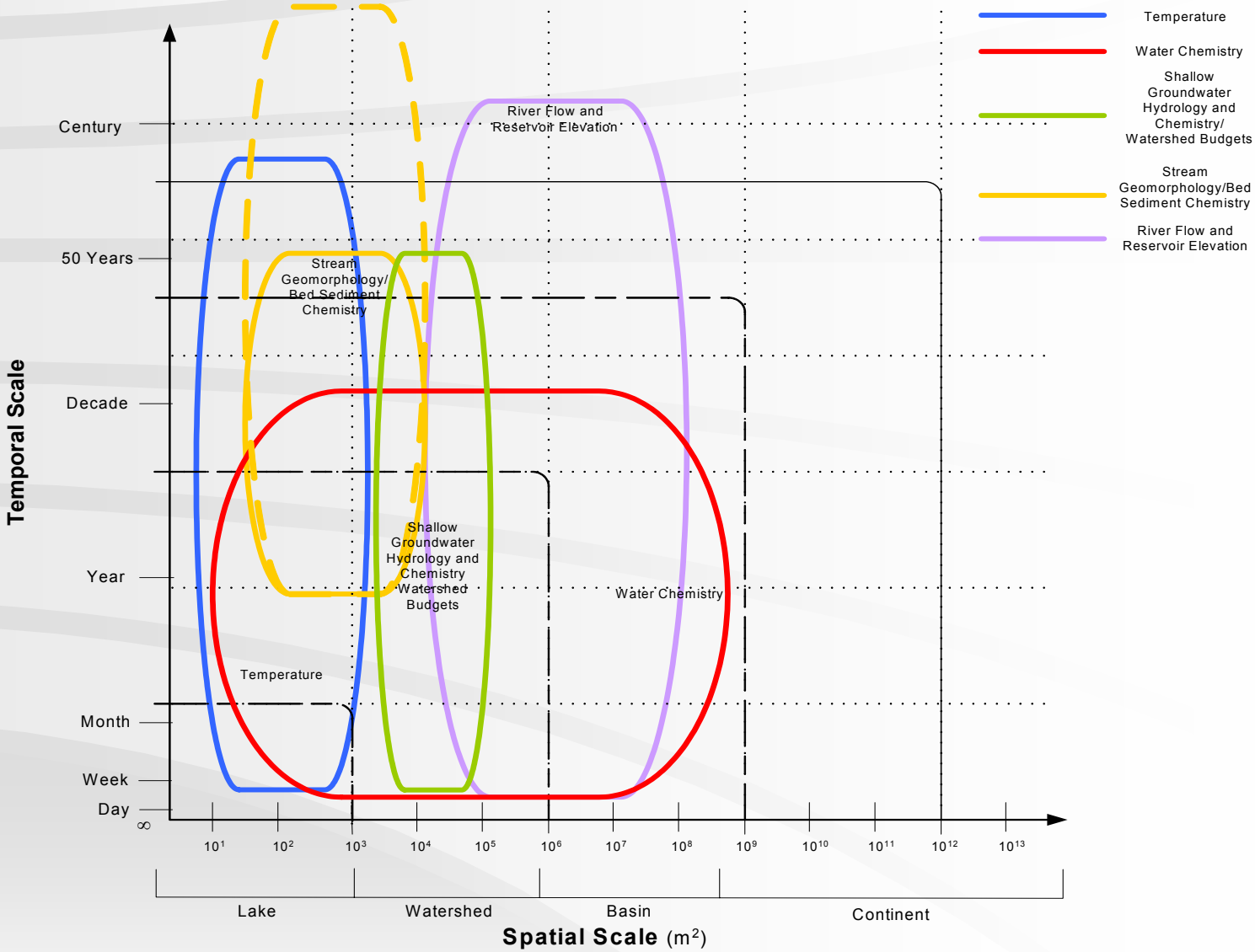
Vital Sign Scoring Methods

- ecological relevance = 25%
- response variability = 25%
- management relevance = 20%
- Feasibility of implementation = 15%
- Interpretation and utility = 15%

- If two criteria, then
  - two yes answers = 1.0 score
  - one yes answer = 0.5 score
  - two no answers = 0.0 score
- If three criteria, then
  - three yes answers = 1.0
  - two yes answers = 0.6
  - one yes answer = 0.3
  - Three 3 answers = 0.0

B	C	D	E	F	G
source / Ecological organization	*Score*	*Candidate Vital Sign*	*GRTE*	*YELL*	*BICA*
Water Quality	1.00	Ground water hydrology	x	x	x
Water Quality	1.00	Reservoir elevation	x		x
Water Quality	1.00	Streamflow	x	x	x
Water Quality	0.95	Algal species composition and biomass	x	x	x
Water Quality	0.95	Continuous water temperature (Lakes and Resevoirs)	x	x	x
Water Quality	0.95	Continuous water temperature (Rivers and Streams; Lakes and Resevoirs)	x	x	x
Water Quality	0.95	Ground water chemistry	x	x	x
Water Quality	0.95	Major ion chemistry (Rivers and Streams; Lakes and Resevoirs)	x	x	x
Water Quality	0.95	River invertebrate assemblages	x	x	x
Terrestrial Vertebrates	1.00	Amphibian occurrence	x	x	x
Terrestrial Vertebrates	1.00	Beaver presence and population estimates	x	x	x
Terrestrial Vertebrates	1.00	Pattern of non-park land-use changes	x	x	x
Terrestrial Vertebrates	0.92	Invasive vertebrate species richness and distribution	x	x	x
Terrestrial Vertebrates	0.92	Vertebrate diseases	x	x	x
Terrestrial Vegetation	1.00	Grassland vegetation community composition and structure	x	x	x
Terrestrial Vegetation	0.95	Alpine plant community characteristics	x	x	
Terrestrial Vegetation	0.95	Lichen distribution, abundance and chemical composition	x	x	x
Terrestrial Vegetation	0.95	Shrubland community composition and structure	x	x	x
Terrestrial Vegetation	0.92	Aspen community composition and structure	x	x	
Terrestrial Vegetation	0.92	Browse effects on riparian woody vegetation	x	x	x
Terrestrial Vegetation	0.92	Fire and fuel loading	x	x	x
Terrestrial Vegetation	0.92	Lodgepole pine plant community composition and exotic species	x	x	
Terrestrial Vegetation	0.92	Mixed conifer plant community composition and exotic species		x	

Aquatics



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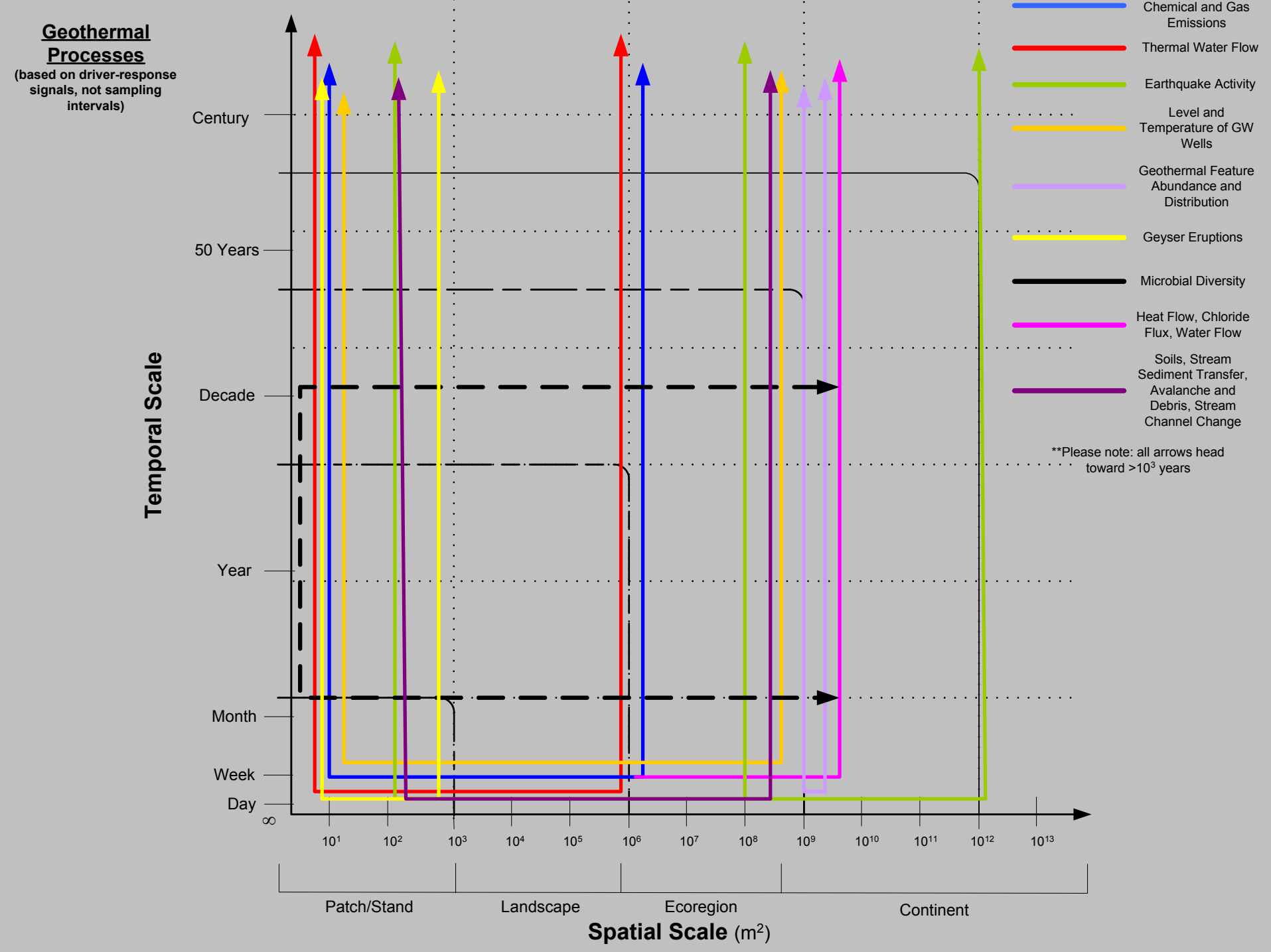
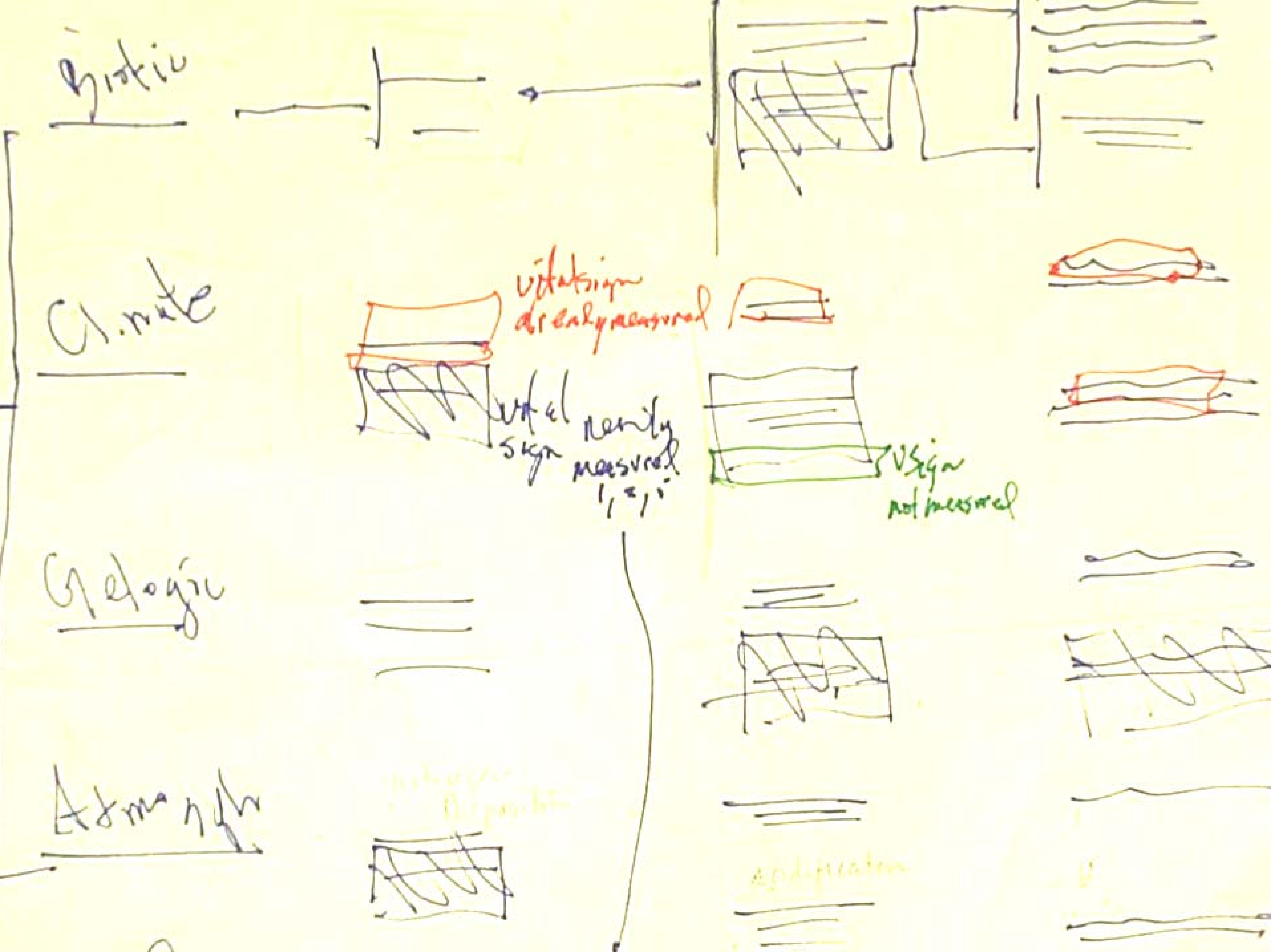
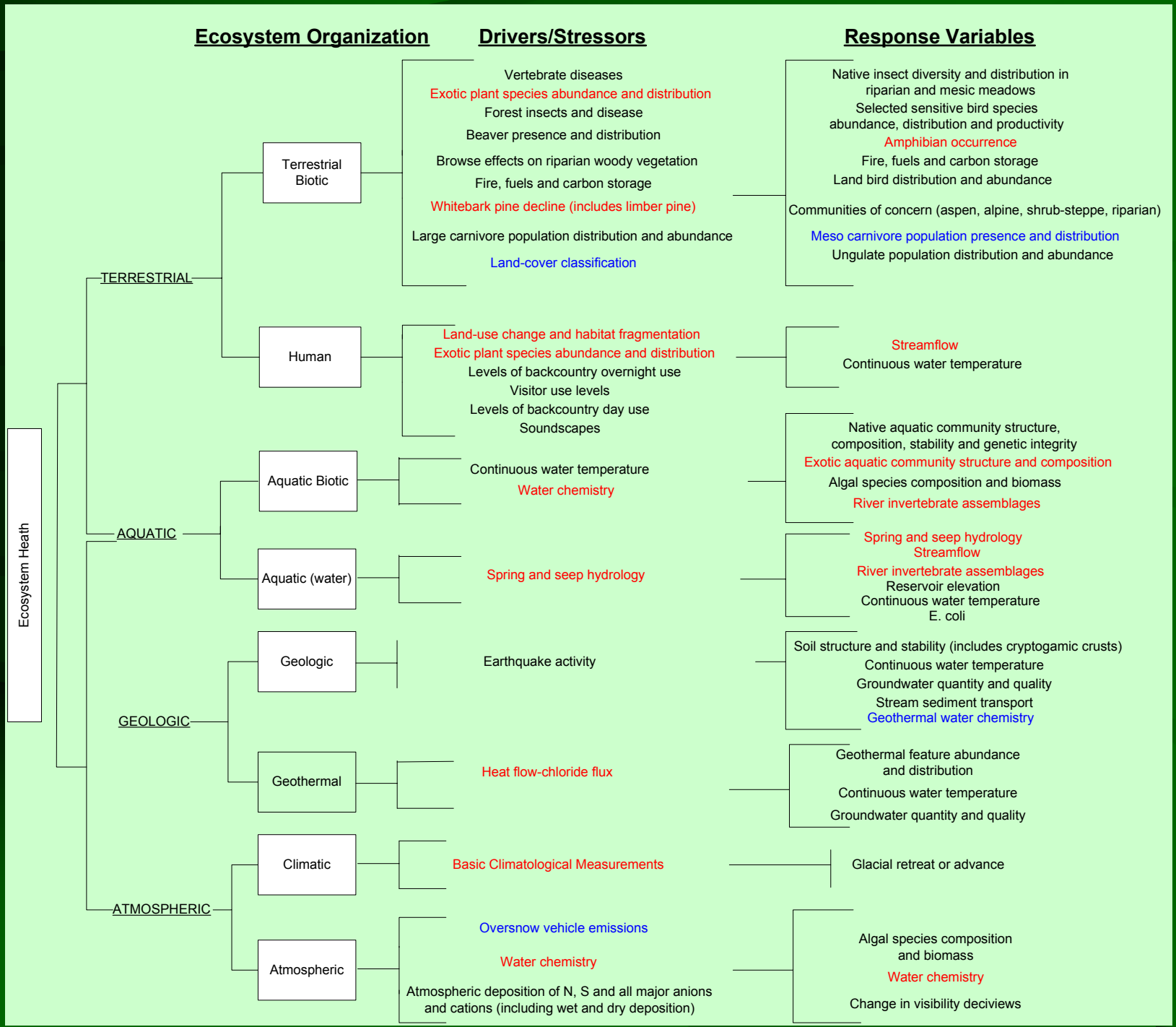

Geothermal Processes
(based on driver-response signals, not sampling intervals)
Temporal Scale
Century
50 Years
Decade
Year
Month
Week
Day
∞
Chemical and Gas Emissions
Thermal Water Flow
Earthquake Activity
Level and Temperature of GW Wells
Geothermal Feature Abundance and Distribution
Geyser Eruptions
Microbial Diversity
Heat Flow, Chloride Flux, Water Flow
Soils, Stream Sediment Transfer, Avalanche and Debris, Stream Channel Change
**Please note: all arrows head toward >10^3 years
10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^10 10^11 10^12 10^13
Patch/Stand
Landscape
Ecoregion
Continent
Spatial Scale (m^2)

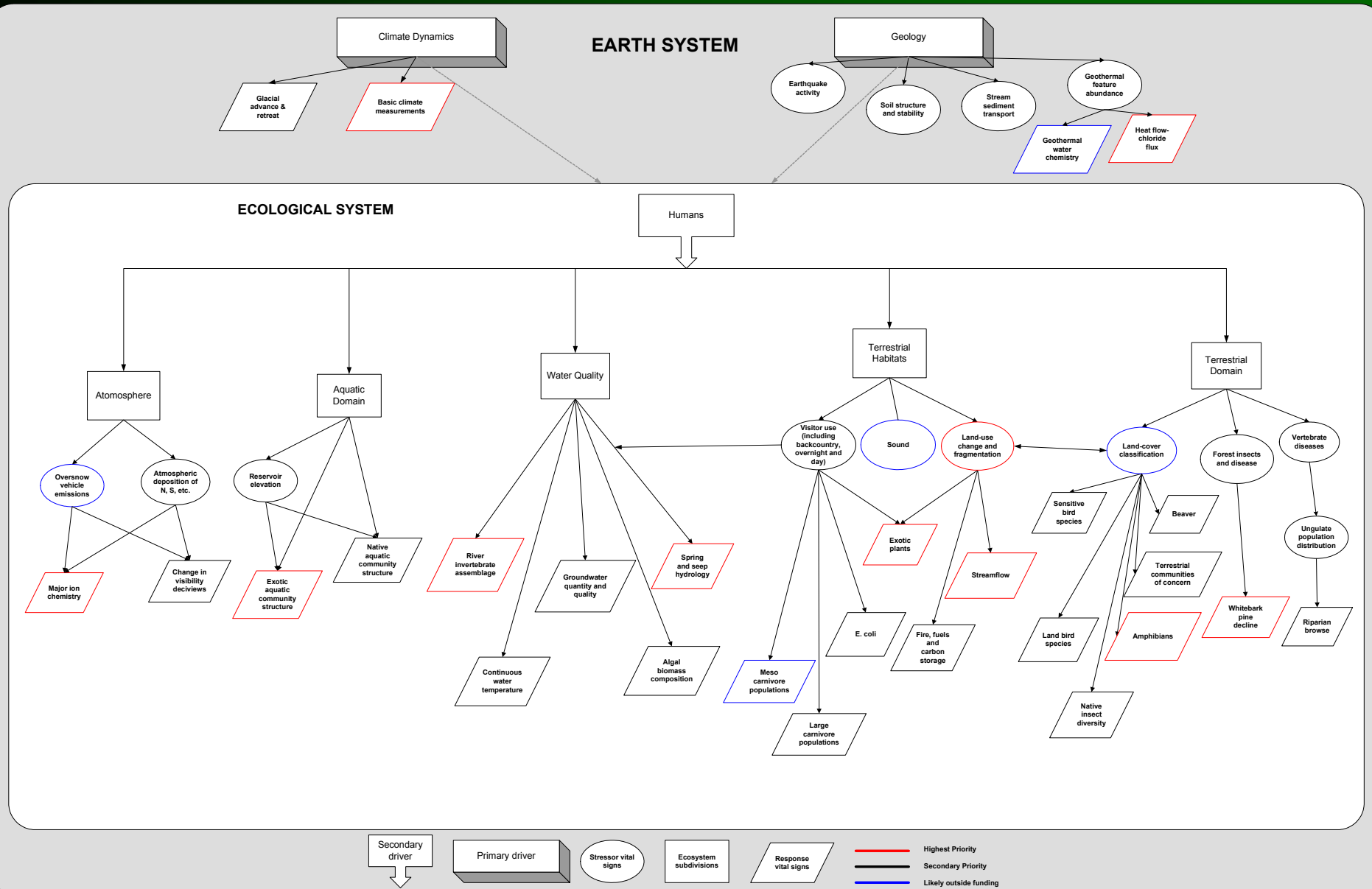
Lessons learned: Prioritizing vital signs

- Experts offered important knowledge and had good discussion on the proposed candidate vital signs
- The use of yes/no questions was key to progress during the workshop.
- A pre-workshop- trail run using the selection criteria can help eliminate questions about semantics and highlight questions that need to be answered before the actual ranking process.

Greater Yellowstone Network I&M Program


Biotic
Climate
vital sign already measured
vital sign
newly measured
V sign
not measured


Ecosystem Organization
Drivers/Stressors
Response Variables
Ecosystem Heath
TERRESTRIAL
AQUATIC
GEOLOGIC
ATMOSPHERIC
Terrestrial Biotic
Human
Aquatic Biotic
Aquatic (water)
Geologic
Geothermal
Climatic
Atmospheric
Vertebrate diseases
Exotic plant species abundance and distribution
Forest insects and disease
Beaver presence and distribution
Browse effects on riparian woody vegetation
Fire, fuels and carbon storage
Whitebark pine decline (includes limber pine)
Large carnivore population distribution and abundance
Land-cover classification
Land-use change and habitat fragmentation
Exotic plant species abundance and distribution
Levels of backcountry overnight use
Visitor use levels
Levels of backcountry day use
Soundscapes
Continuous water temperature
Water chemistry
Spring and seep hydrology
Earthquake activity
Heat flow-chloride flux
Basic Climatological Measurements
Oversnow vehicle emissions
Water chemistry
Atmospheric deposition of N, S and all major anions and cations (including wet and dry deposition)
Native insect diversity and distribution in riparian and mesic meadows
Selected sensitive bird species abundance, distribution and productivity
Amphibian occurrence
Fire, fuels and carbon storage
Land bird distribution and abundance
Communities of concern (aspen, alpine, shrub-steppe, riparian)
Meso carnivore population presence and distribution
Ungulate population distribution and abundance
Streamflow
Continuous water temperature
Native aquatic community structure, composition, stability and genetic integrity
Exotic aquatic community structure and composition
Algal species composition and biomass
River invertebrate assemblages
Spring and seep hydrology
Streamflow
River invertebrate assemblages
Reservoir elevation
Continuous water temperature
E. coli
Soil structure and stability (includes cryptogamic crusts)
Continuous water temperature
Groundwater quantity and quality
Stream sediment transport
Geothermal water chemistry
Geothermal feature abundance and distribution
Continuous water temperature
Groundwater quantity and quality
Glacial retreat or advance
Algal species composition and biomass
Water chemistry
Change in visibility deciviews


EARTH SYSTEM
Climate Dynamics
Glacial advance & retreat
Basic climate measurements
Geology
Earthquake activity
Soil structure and stability
Stream sediment transport
Geothermal feature abundance
Geothermal water chemistry
Heat flow-chloride flux
ECOLOGICAL SYSTEM
Humans
Atmosphere
Oversnow vehicle emissions
Atmospheric deposition of N, S, etc.
Major ion chemistry
Change in visibility deciviews
Aquatic Domain
Reservoir elevation
Native aquatic community structure
Exotic aquatic community structure
Water Quality
River invertebrate assemblage
Groundwater quantity and quality
Spring and seep hydrology
Continuous water temperature
Algal biomass composition
Terrestrial Habitats
Visitor use (including backcountry, overnight and day)
Sound
Land-use change and fragmentation
Exotic plants
Streamflow
Meso carnivore populations
E. coli
Fire, fuels and carbon storage
Large carnivore populations
Terrestrial Domain
Land-cover classification
Forest insects and disease
Vertebrate diseases
Sensitive bird species
Beaver
Ungulate population distribution
Terrestrial communities of concern
Whitebark pine decline
Riparian browse
Land bird species
Amphibians
Native insect diversity
Secondary driver
Primary driver
Stressor vital signs
Ecosystem subdivisions
Response vital signs
Highest Priority
Secondary Priority
Likely outside funding